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EVALUATION OF WASTE ACTIVATED SLUDGE (CITRUS) AS A POULTRY FEED INGREDIENT

1. PERFORMANCE OF CHICKS, BROILERS AND LAYING HENS[1]

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ABSTRACT

A series of feeding trials were conducted to study the use of activated citrus sludge in practical-type broiler and laying hen diets. These experiments were divided into two 28-day chick trials, a 56-day broiler study, and a 168-day feeding period with laying hens.

In the first chick experiment diets containing 0, 2.5, 5, 10, 15 or 20% citrus sludge were fed. In the second chick experiment birds received diets containing 0, 2.5, 5, 10 or 20% sludge, with a sixth treatment of 20% sludge plus additional methionine and lysine. Diets containing 2.5, 5 or 10% citrus sludge were used in the broiler study. Data from all experiments indicated that a dietary level of citrus sludge between 5 and 10% did not adversely affect bird performance.

A total of 180 laying hens were fed diets containing 0, 2.5, 5.0, 7.5 or 20% citrus sludge. Inclusion of up to 7.5% sludge in the diet did not significantly affect hen-day egg production, egg weight, daily feed intake, or feed efficiency. No significant differences due to treatment were found in specific gravity of the eggs. Haugh unit scores were numerically increased as the level of sludge in the diet increased through 7.5%. Mortality was not affected by the inclusion of up to 20% citrus sludge in the diet.

INTRODUCTION

Research has been conducted on the use of activated sludge in animal feeds for more than 20 years. The material can be used as a concentrated source of nitrogen for the ruminant animal. Even though the biological value of its protein has been determined to be about 50%, research with rumimants has indicated that nitrogen retention from activated sludge is equal to that from soybean meal or urea (Hurwitz)(1). Swine feeding trials with synthetic diets have indicated that a level of 2% sludge provides a satisfactory level of vitamin B_{12}.

Studies with chicks (Hurwitz)(1) indicated that as little as 1% sludge would furnish an adequate amount of vitamin B_{12} for normal growth. Levels of up to 3% sludge gave an additional response which could not be attributed to the presence of vitamin B_{12} alone, and was felt to indicate the presence of unknown growth factors; possibly due to the fermentation process involved. Orme and Lemm (2), using dried sludge from

[1]Florida Agr. Exp. Sta. Journal Series No. 4045

paper processing waste, found that it had potential as a protein ingredient in rainbow trout feeds.

The following experiments were conducted to study the use of citrus sludge in the diet of broilers and laying hens.

CHICK STUDIES

Experimental Procedure: Before feeding trials were started, the basic nutrient analysis of the sludge was determined by a commercial laboratory (Table 1) and used as a basis of dietary formulation. Amino

Table 1. Nutrient analysis of citrus sludge

	%
Moisture	6.30
Protein	38.6
Crude Fiber	12.6
Calcium	1.49
Phosphorus	1.59
Methionine[1]	0.50
Cystine[1]	0.20
Lysine[1]	1.30
Metabolizable energy (Kcal./Kg.)[2]	1760

[1]Hackler et al. (1957).

[2]Estimate based on established values for comparable materials.

acids were obtained from the literature concerning sewage sludge (Hackler et al.)(3). A value for metabolizable energy was not available in the literature and was estimated from examining the energy content established for comparable materials.

Two experiments were conducted in electrically heated battery brooders with ten chicks in each pen. For each of the two experiments four replicate pens, each containing five male and five female day-old Cobb color-sexed broiler-type chicks, were assigned dietary treatments consisting of various levels of citrus sludge for a 28-day feeding period.

In the first experiment, birds received corn-soybean meal type diets containing 0, 2.5, 5, 10, 15 or 20% citrus sludge (Table 2). All diets in the series were calculated to contain 23% protein, 1.1% calcium, 0.755% total phosphorus, 0.88% total sulfur amino acids and 3,012 kilocalories of metabolizable energy per kilogram of feed.

The dietary treatments of the second experiment (Table 2) consisted of levels of 0, 2.5, 5, 10 or 20% sludge, with a sixth treatment of 20% sludge plus additional methionine and lysine (0.38% and 0.26%, respectively). The latter diet was included to determine if sulfur amino acid or lysine availability might be a limiting factor, and will be subsequently referred to as the "20%+" diet. As in the first experiment all but

Table 2. Chick and broiler diet composition

Ingredients	Composition of Diets 0%	2.5%	5%	10%	15%	20%
Yellow corn	54.97	53.81	52.71	50.40	48.15	45.94
Soybean meal (48.5%)	36.50	34.71	32.87	29.28	25.65	21.98
Alfalfa meal (17%)	2.50	2.50	2.50	2.50	2.50	2.50
Citrus sludge	0	2.50	5.00	10.00	15.00	20.00
Ground limestone	0.74	0.79	0.82	0.89	0.96	1.05
Defluorinated phosphate (18% P and 32% Ca)	2.11	1.95	1.81	1.52	1.23	0.92
Iodized salt	0.40	0.40	0.40	0.40	0.40	0.40
Microingredient mix[1]	0.50	0.50	0.50	0.50	0.50	0.50
Animal fat	2.15	2.70	3.23	4.33	5.40	6.47
DL-methionine	0.13	0.14	0.16	0.18	0.21	0.25
Lysine	0	0	0	0	0	0

[1]Supplied per kilogram of diet: 6,600 I.U. vitamin A, 2,200 I.C.U. vitamin D_3, 500 mg. choline chloride, 40 mg. niacin, 4.4 mg. riboflavin, 13 mg. pantothenic acid, 22 mcg. vitamin B_{12}, 125 mg. ethoxyquin, 20 mg. iron, 2 mg. copper, 200 mcg. cobalt, 1.1 mg. iodine, 100 mcg. zinc, 71 mg. manganese, and 2.2 mg. menadione sodium bisulfite.

the "20%+" diet were calculated to be isonitrogenous, isocaloric and meet all other requirements. Statements of probability for these experiments and throughout the paper are based on the analysis of variance as described by Snedecor (4) with significant differences between treatment means being determined by the multiple range test of Duncan (5).

Results and Discussion: Inclusion of up to 10% citrus sludge in the diet of chicks did not significantly affect body weights (Table 3).

Table 3. Performance of chicks fed diets containing various levels of citrus sludge (Exp. 1)

Treatment (% sludge)	Body wt.[1] (g.)	Feed/bird/day (g.)	G. feed/g. body wt.[1]
0	411^{ab}	30.4	1.48^{a}
2.5	413^{a}	29.6	1.45^{a}
5.0	409^{abc}	29.6	1.45^{a}
10.0	403^{abcd}	30.5	1.51^{ab}
15.0	390^{cd}	31.0	1.59^{b}
20.0	365^{e}	31.6	1.74^{c}

[1]Means without common letters are significantly different according to Duncan's multiple range test ($P < .05$).

Weights of birds receiving 15% citrus sludge were not significantly different from those fed either the 5 or 10% sludge treatments; however, birds receiving the diet with 20% sludge weighed significantly less than any other treatment group.

There were no significant treatment differences among daily feed consumption values in Experiment 1 (Table 3). Including up to 10% citrus sludge in the diet did not significantly affect feed efficiency. The feed efficiency value for birds receiving 15% sludge was not significantly different from the value for the 10% sludge diet, but was different from those obtained for all other diets. Feed efficiency of birds receiving a diet containing 20% sludge was significantly higher than all other treatments.

There were no significant differences among the body weights of birds receiving diets containing either 0, 2.5 or 5% sludge (Table 4).

Table 4. Performance of chicks fed diets containing various levels of citrus sludge (Exp. 2)

Treatment (% sludge)	Body wt.[1] (g.)	Feed/bird/day (g.)	G. feed/g. body wt.[1]
0	455^{ab}	35.8	1.64^{abc}
2.5	460^{ab}	35.6	1.52^{a}
5.0	472^{a}	37.3	1.66^{abc}
10.0	414^{c}	34.4	1.75^{cd}
20.0	423^{c}	37.2	1.83^{d}
20.0 + Lysine & Methionine	425^{c}	35.3	1.74^{bcd}

[1]Means without common letters are significantly different ($P < .05$) according to Duncan's multiple range test.

Weights of treatment groups receiving above 5% sludge in the diet were all significantly below those of the lower sludge levels, but did not differ statistically from each other.

There were no significant differences among daily feed intake values for birds receiving any of the dietary treatments (Table 4). There were no significant differences among the feed efficiency values of birds receiving either 0, 2.5 or 5% sludge in the diet. Efficiency values for birds receiving diets containing 10, 20 or the "20+" diets did not differ significantly. It appeared that levels in excess of 5% sludge adversely affected feed efficiency. Mortality was not affected by the inclusion of up to 20% citrus sludge in the diet.

These data indicate that levels of between 5 and 10% sludge could be included in the diet of starting broiler chicks without adversely affecting growth or other performance criteria.

BROILER STUDY

Experimental procedure: Treatments consisted of a basal diet and diets containing either 2.5, 5 or 10% citrus sludge. The diets used were identical in composition to those of the previous chick studies, (Table 2) with the exception of the inclusion of a small amount of coccidiostat at the expense of yellow corn. Three replicate floor pens, each containing 10 male and 10 female day-old broiler chicks, received

each dietary treatment for the 56-day feeding period. Each pen contained 2.32 square meters of floor space, 1 hanging feeder and 1 automatic water fountain.

Results and Discussion: No significant differences were found among 56-day body weights (Table 5). Daily feed intake and feed efficiency values were not significantly influenced by treatment. These

Table 5. Performance of broilers fed diets containing various levels of citrus sludge (8 wks.)

% Sludge	Body wt. (g.)	Feed/bird/day[1] (g.)	g. feed/g. body wt.
0	1750	66[ab]	2.16
2.5	1772	63[a]	2.08
5.0	1800	67[b]	2.16
10.0	1732	68[b]	2.25

[1]Means without common letters are significantly different ($P < .05$) according to Duncan's multiple range test.

data substantiate the chick trials in that a level of sludge between 5 and 10% can be used in the diet of broilers.

LAYING HEN STUDY

Experimental Procedure: Eight replicate groups of five individually caged hens were fed each of four dietary treatments containing 0, 2.5, 5.0 or 7.5% citrus sludge in a corn-soybean meal type diet. A level of 20% sludge was also fed to four replicate five-bird groups. Composition of the diets is shown in Table 6. All diets were calculated to be equal in protein, calcium, phosphorus, sulfur containing amino acids and energy. The experiment was conducted for six 28-day periods. Individual daily egg records were kept for each hen and summarized at the end of each 28-day period. Values for hen-day egg production, egg weight, daily feed intake, feed efficiency, egg specific gravity and Haugh units were obtained at 28-day intervals. The technique of Novikoff and Gutteridge (6) was used for specific gravity determination with salt solutions ranging from 1.060 to 1.095 specific gravity in increments of 0.005. Haugh unit calculations were performed by computer using the formula reviewed by Eisen et al. (7).

Results and Discussion: Egg production was not affected by the addition of up to 7.5% sludge in the diet (Table 7); however, the use of 20% sludge caused a significant depression of egg production. There was no significant effect upon daily feed intake or feed efficiency until 20% sludge was included in the diet. Also, no significant specific gravity differences due to treatment were found (Table 7). Haugh unit scores were increased as the level of sludge in the diet increased through 7.5% (Table 7). These scores from hens receiving either 5 or 7.5% citrus sludge in the diet were significantly higher than those

Table 6. Laying hen diet composition (%)

Ingredients	0%	20%
Yellow corn	66.50	58.00
Soybean meal (50%)	17.96	3.34
Alfalfa meal (17%)	2.50	2.50
Citrus sludge	0	20.00
Ground limestone	6.77	6.98
Defluorinated phosphate (18% P and 32% Ca)	1.94	0.80
Iodized salt	0.40	0.40
Microingredient mix[1]	0.50	0.50
Animal fat	1.10	5.22
Washed builder's sand	2.27	2.093
DL-methionine	0.06	0.167

[1]Supplied per kilogram of diet: 6,600 I.U. vitamin A, 2,200 I.C.U. vitamin D_3, 500 mg. choline chloride, 40 mg. niacin, 4.4 mg. riboflavin, 13 mg. pantothenic acid, 22 mcg. vitamin B_{12}, 125 mg. ethoxyquin, 20 mg. iron, 2 mg. copper, 200 mcg. cobalt, 1.1 mg. iodine, 100 mcg. zinc, 71 mg. manganese and 2.2 mg. menadione sodium bisulfite.

Table 7. Performance of laying hens fed diets containing various levels of citrus sludge (6 months)

Treatment (% Sludge)	Av. egg prod.[1] (%)	Egg wt.[1] (gms.)	Feed/ bird/ day[1] (gms.)	Feed/ doz. eggs[1] (kg.)	Specific Gravity	Haugh Units
0	69.61^{a}	62.9^{a}	113^{a}	2.00^{a}	1.0792	64.3^{a}
2.5	68.32^{a}	63.4^{a}	109^{a}	1.98^{a}	1.0801	67.4^{ab}
5.0	67.01^{a}	63.6^{a}	114^{a}	2.13^{a}	1.0787	69.4^{b}
7.5	69.21^{a}	63.3^{a}	112^{a}	2.01^{a}	1.0780	68.9^{b}
20.0	42.12^{b}	59.0^{b}	92^{b}	2.86^{b}	1.0781	82.0^{c}

[1]Means without common letters are significantly different ($P < .05$) according to Duncan's multiple range test.

of the control levels. The extremely high value from hens receiving a diet containing 20% sludge was attributed to lowered egg production, since interior egg quality is normally inversely related to the bird's level of egg production.

These data indicated that citrus sludge levels of 5 to 7.5% were acceptable in poultry feeds, when usage was based on its nutrient analysis. Levels above 10% sludge depressed performance and the addition of sulfur amino acids and lysine did not correct this condition. It would appear that the value of 1760 kilocalories of metabolizable energy which was assumed for this product at the outset is approximately correct.

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